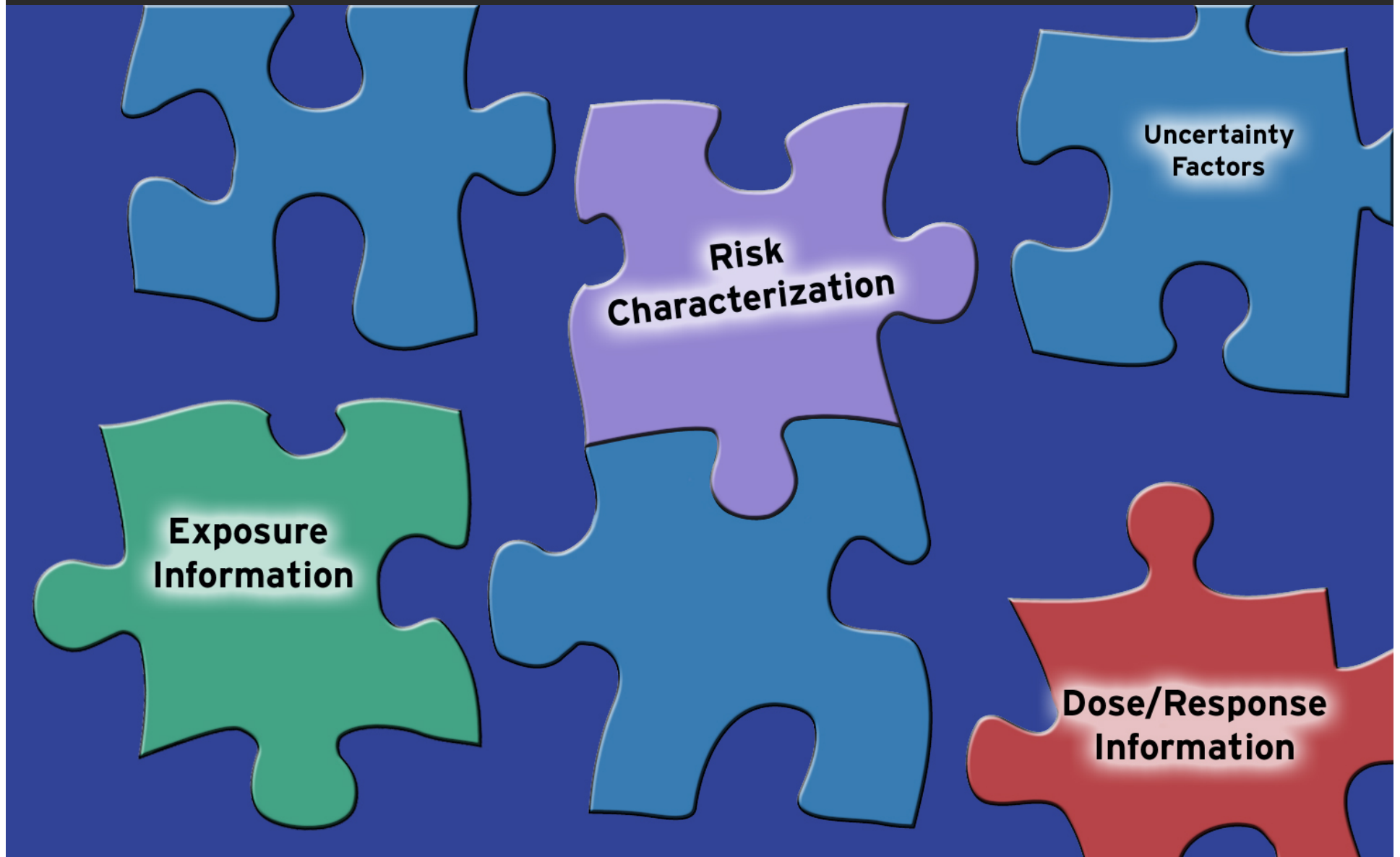


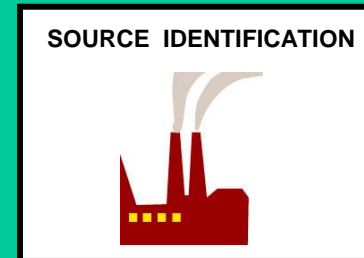
Risk Characterization for Air Toxics



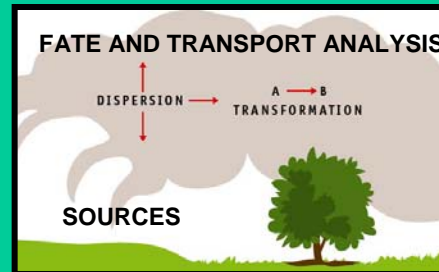
The Detailed Air Toxics Risk Assessment Process

Planning and Scoping

Exposure Assessment



Chemical Release

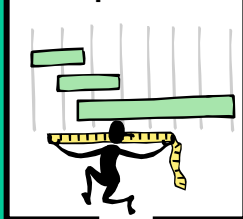


CHEMICAL CONCENTRATIONS
Air, Soil, Water, Food
(monitor/model)

POPULATION CHARACTERISTICS



Measures of Exposure

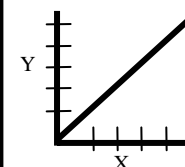


Toxicity Assessment

Hazard Identification



Dose/Response Assessment



Risk Characterization

EXPOSURE
information

DOSE/RESPONSE
information

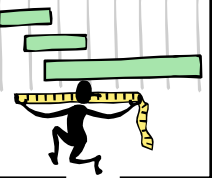
Quantitative and Qualitative Expressions of Risk/Uncertainty

The Detailed Air Toxics Risk Assessment Process

Planning and Scoping

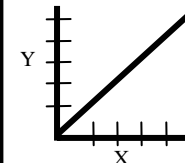
Exposure Assessment

Measures of Exposure



Toxicity Assessment

Dose/
Response
Assessment



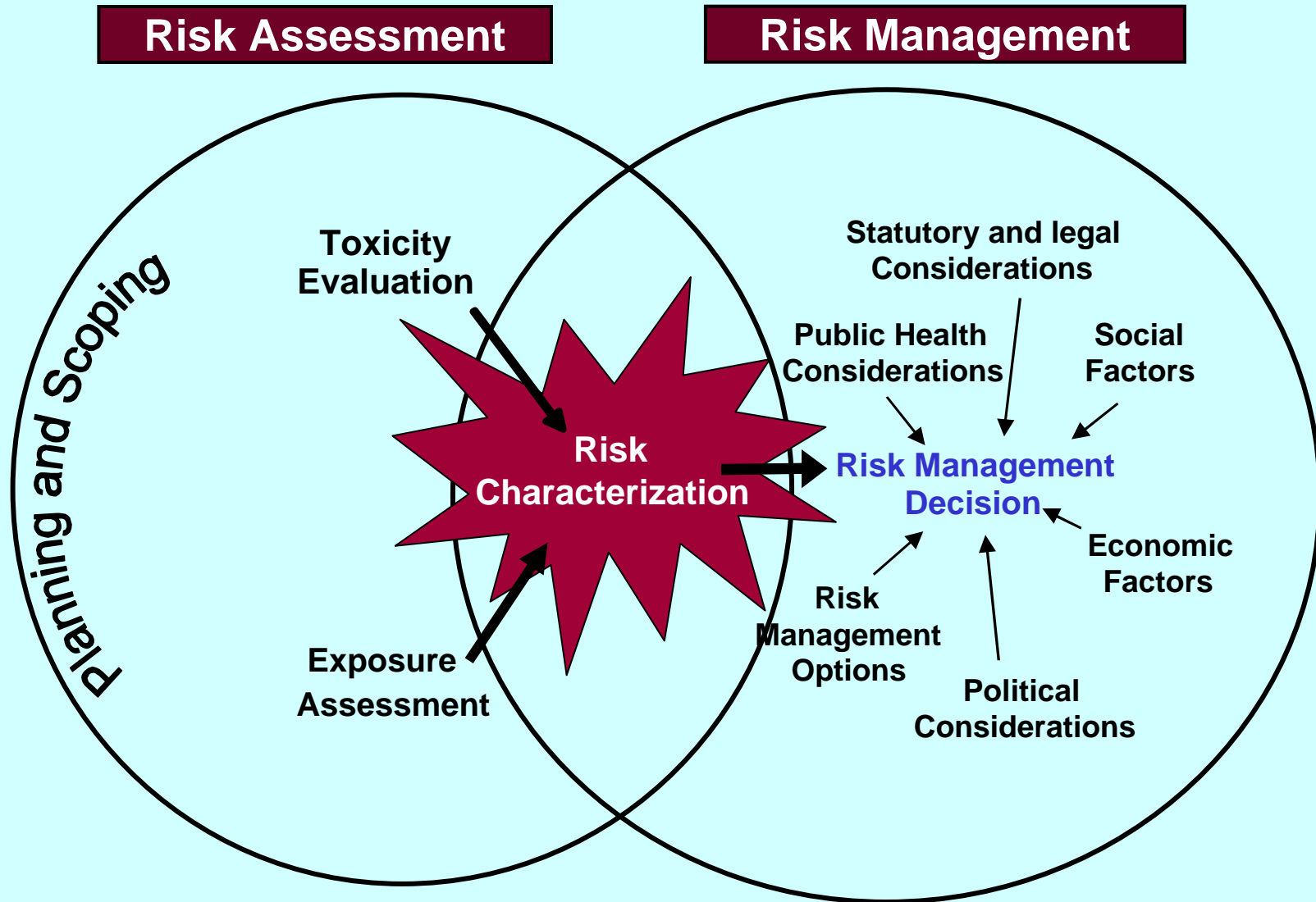
Risk Characterization

EXPOSURE
information

DOSE/RESPONSE
information

Quantitative and Qualitative Expressions of Risk/Uncertainty

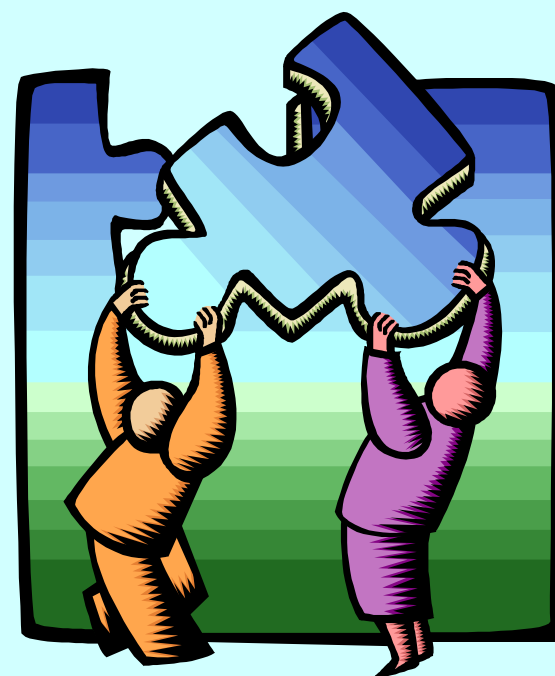
So, just what is the risk?



The Major Steps... Putting it all together

Review and combine the outputs from toxicity and exposure assessments

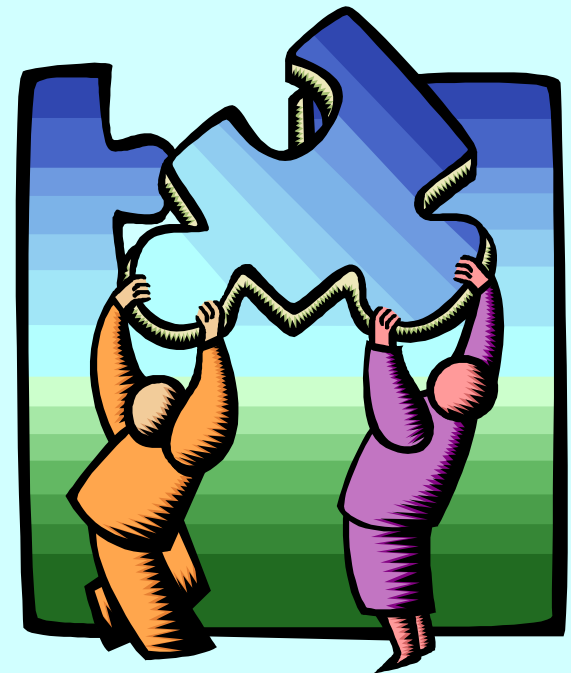
- Quantify risks from individual chemicals for each pathway separately (e.g., inhalation, ingestion), then...
- Combine risks from multiple chemicals within each pathway, then...
- Combine risks across exposure pathways to give total risk



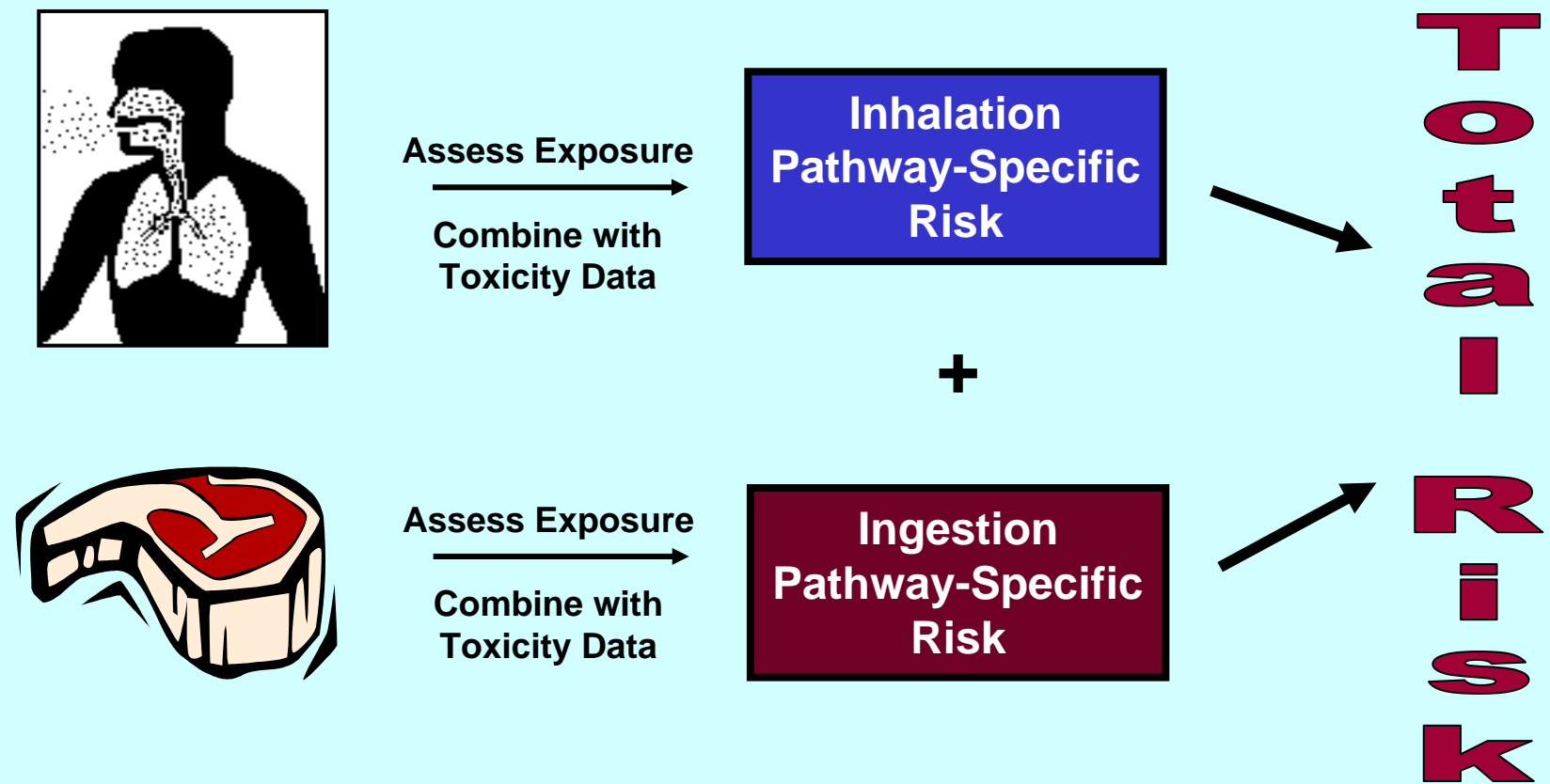
The Major Steps... Putting it all together

**Present the risk results in
tabular and narrative form**

Assess and present uncertainty



Example – Multipathway Risk Characterization



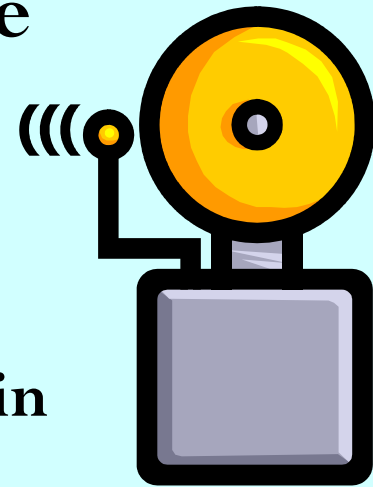
Remember!!!

We normally go through this entire process twice!!!

First, we calculate and present the risks posed by cancer causing chemicals within and then across pathways

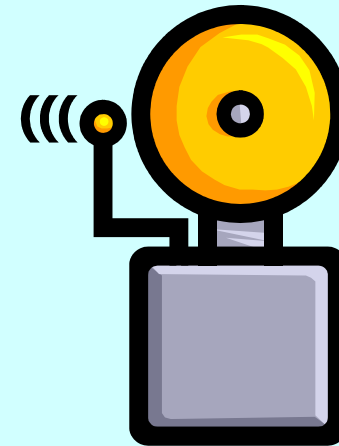
...and next, we...

Calculate and present the noncancer hazards posed by various chemicals within and then across pathways



Remember!!!

Cancer risks are presented separately from noncancer hazards



Some chemicals may show up in both sets of analyses because some chemicals can cause both cancer and noncancer effects



Risk Characterization –Focus on Inhalation



- Air toxics risk characterization will always assess the inhalation pathway, so we will focus on this first
- Risk Characterization of other pathways is only done if limited number of specific HAPs has been released to the air
- And remember.... we calculate cancer and noncancer separately!

Inhalation Cancer Risk

How do you usually calculate it?

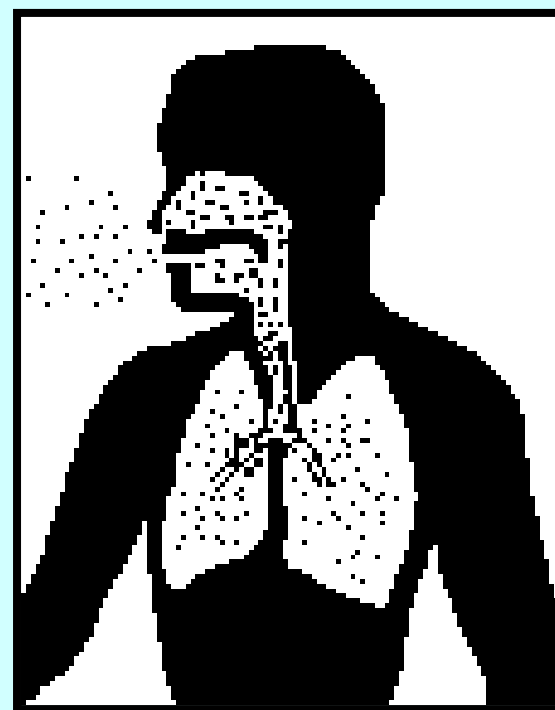
The basic equation for calculating risk from breathing a carcinogenic air toxic is:

$$\text{Risk} = \text{EC} \times \text{IUR}$$

Where:

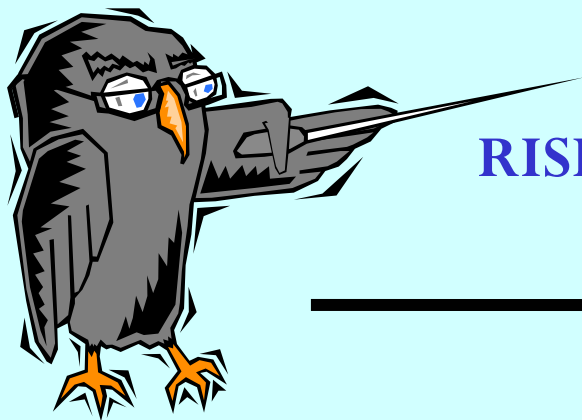
EC = concentration of the chemical in air at the point of exposure (ug/m^3)

IUR = Inhalation Unit Risk ($\text{risk}/\text{ug}/\text{m}^3$)



Example – SMASH and GASP

SMASH Exposure Concentration = $1 \mu\text{g}/\text{m}^3$
IUR = 2×10^{-3} per $\mu\text{g}/\text{m}^3$
Class C Possible carcinogen



$$\text{RISK} = (1 \text{ ug}/\text{m}^3) \times (2 \times 10^{-3} / \text{ug}/\text{m}^3) = 0.002$$

GASP Exposure = $5 \mu\text{g}/\text{m}^3$
IUR = 2×10^{-5} per $\mu\text{g}/\text{m}^3$
Class A Known Human Carcinogen

$$\text{RISK} = (5 \text{ ug}/\text{m}^3) \times (2 \times 10^{-5} / \text{ug}/\text{m}^3) = 0.0001$$

Inhalation Cancer Risk

What happens when multiple carcinogens are present?

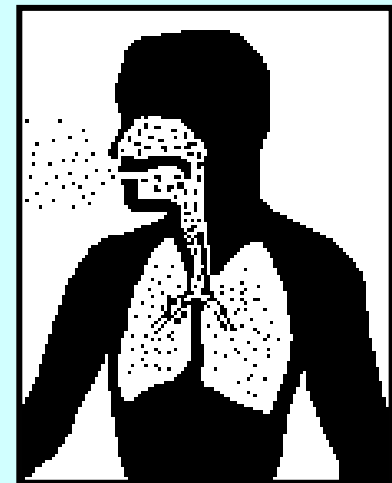
The equation is the same – however, you usually sum over all the different carcinogens present in the air

$$\text{Risk} = (\text{EC}_1 \times \text{IUR}_1) + (\text{EC}_2 \times \text{IUR}_2) + \dots + (\text{EC}_i \times \text{IUR}_i)$$

Where:

EC_i = concentration of the i^{th} chemical in the air at the point of exposure ($\mu\text{g}/\text{m}^3$)

IUR_i = Inhalation Unit Risk of the i^{th} chemical in the air ($\text{risk}/\mu\text{g}/\text{m}^3$)



Cancer Risk

What do the answers mean?

Cancer risk is a *probability* (e.g., 2×10^{-5}) of an individual developing cancer because of the exposure in question



Cancer Risk

What do the answers mean?

The answer you get is the *excess risk to an individual* at the point where “EC” is either measured (by monitoring) or estimated (by modeling)



Cancer Risk

What do the answers mean?

Population at risk, on the other hand, is an estimate of the number of people living at a given risk level (for example, if you use modeling to estimate “EC” at a census block centroid, all the people in that census block are described as having that risk)



Inhalation NonCancer Hazard

How do you usually calculate it?

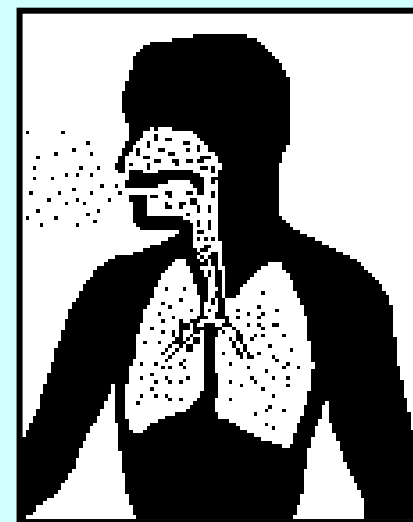
The basic equation for calculating hazard from breathing an air toxic that causes a noncancer effect is:

$$\text{Hazard Quotient} = \text{EC} / \text{RfC}$$

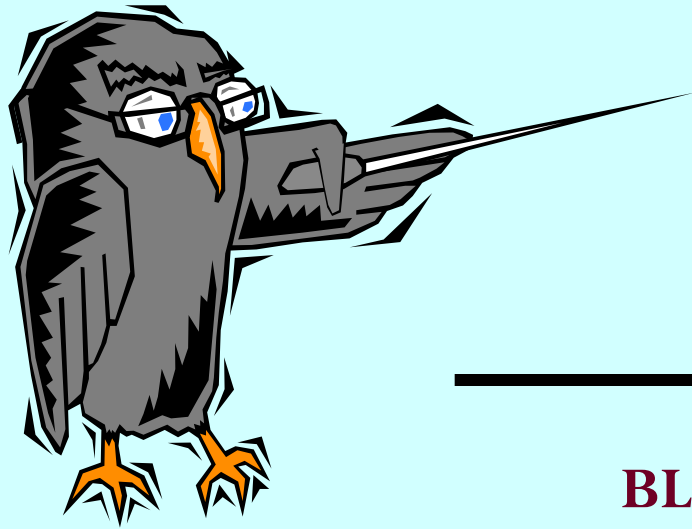
Where:

EC = concentration of the chemical in air at the point of exposure (mg/m^3)

RfC = Reference Concentration (mg/m^3)



Example – CHOKE & BLOAT



CHOKE Reduced kidney function

$$EC = 2 \text{ mg/m}^3$$

$$RfC = 1 \text{ mg/m}^3$$

$$UF = 30$$

$$HQ = (2 \text{ mg/m}^3) \div (1 \text{ mg/m}^3) = 2$$

BLOAT Reduced liver function

$$EC = 10 \text{ mg/m}^3$$

$$RfC = 2 \text{ mg/m}^3$$

$$UF = 1000$$

$$HQ = (10 \text{ mg/m}^3) \div (2 \text{ mg/m}^3) = 5$$

NonCancer Hazard

What happens when multiple noncarcinogens are present?

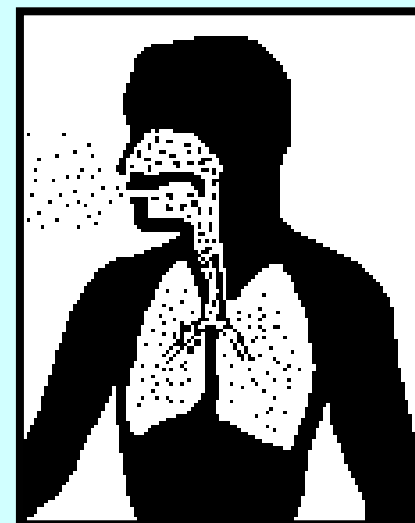
The equation is the same – however, you usually sum over all the different noncarcinogens present in the air (note the new name for the sum)

$$\text{Hazard Index} = (EC_1)/(RfC_1) + (EC_2)/(RfC_2) + \dots + (EC_i)/(RfC_i)$$

Where:

EC_i = concentration of the i^{th} chemical in the air at the point of exposure (mg/m^3)

RfC_i = reference concentration of the i^{th} chemical in the air (mg/m^3)



NonCancer Hazard

What do hazard answers mean?

The HQ is a simple comparison (i.e., a ratio) of a chemical's concentration in air to a level below which no adverse effect is likely to occur in the general population, including sensitive subpopulations

The HQ **IS NOT** a unitless probability like cancer risk - that is why you cannot add cancer *risk* and noncancer *hazard* (they're apples and oranges!)

The letters 'HQ' are rendered in a large, bold, maroon-colored font. The letters have a slight 3D effect with a dark shadow cast beneath them, making them appear to float above the light blue background.

NonCancer Hazard

What do hazard answers mean?

The level of hazard associated with an $HQ > 1$ does not necessarily increase linearly with an increasing ratio

HQ

NonCancer Hazard

What do hazard answers mean?

The answer you get is the *hazard to an individual* at the point where “EC” is either measured (by monitoring) or estimated (by modeling)



NonCancer Hazard

What do hazard answers mean?

Population hazard, on the other hand, is an estimate of the number of people living at a given hazard level (for example, if you use modeling to estimate “EC” at a census block centroid, all the people in that census block are described as having that hazard)



The TOSHI



If the initial HI calculation gives an $HI \geq 1$, a target organ specific hazard index (TOSHI) may be warranted to clarify the potential impact of multi-chemical exposures on the exposed person, since not all chemicals affect the same organs or have the same mechanism of toxicity



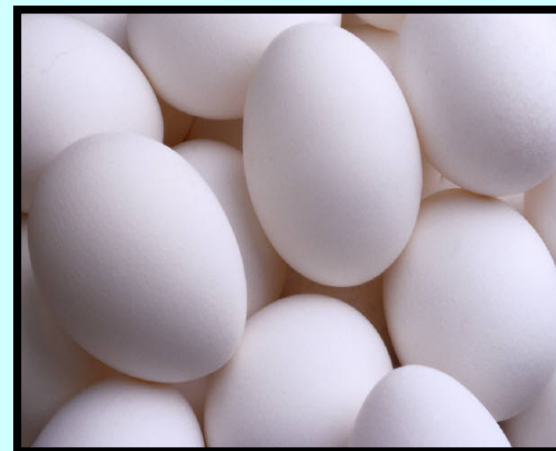
A toxicologist with experience in this area should perform this analysis

Non-inhalation pathways

Some HAPs may deposit out of the air and result in potentially dangerous levels other media such as soil, water, or food

- Only evaluate for HAPs that are persistent and which may also bioaccumulate, such as mercury and dioxin.

The risk analysis for non-inhalation pathways is usually much more complicated than for the inhalation pathway



Non-inhalation pathways

Generally, we use modeling to estimate concentrations of HAPs in these other media

Limited monitoring is sometimes done to validate the modeling



No Toxicity Data?

For chemicals with no toxicity data, several possibilities exist:

- Exclude from analysis and discuss as an uncertainty (most often done)
- Derive a toxicity value
 - “From scratch” using good-quality toxicological or epidemiological studies, accepted mathematical models
 - Use a “surrogate” toxicity value (a known toxicity value for another chemical that is thought to behave toxicologically like the chemical in question)
 - Estimate a “scaled value” based on structure-activity relationship [e.g., toxicity equivalency factors (TEQs) for dioxin and certain PCB congeners]

A toxicologist should perform these analyses



How correct are our risk estimates?



Perform a thorough evaluation of uncertainties associated with the assessment

How do they affect the results (direction and magnitude)?

Uncertainty analysis is one of the main steps of the risk characterization process

Dealing with Uncertainty

Uncertainty arises from lack of knowledge; beyond a certain point, data doesn't help

Identify and evaluate important areas of uncertainty



Some Important Areas of Uncertainty

- **Physical setting uncertainties**
 - Likelihood that exposure pathways are occurring
 - Sources and chemicals not included in the assessment
- **Model applicability and assumptions**
- **Parameter value uncertainties**
- **Toxicity assessment uncertainties**
 - Multiple substance exposures
 - Chemicals with no toxicity values
 - TOSHI analyses

